An Autoregressive Cross-Lagged Model Unraveling Co-Occurring Stimulant Use and HIV: Results from a Randomized Controlled Trial

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Abstract

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Background: Evidence-based interventions are needed to address the use of stimulants such as methamphetamine as a driver of onward HIV transmission and faster clinical HIV progression among sexual minority men. Prior randomized controlled trials with people living with HIV who use substances indicate that financial incentives provided during contingency management (CM) are effective for achieving short-term reductions in stimulant use and HIV viral load. However, the benefits of CM are often not maintained after financial incentives for behavior change end.

Purpose: Data from a recently completed randomized controlled trial with 110 sexual minority men living with HIV who use methamphetamine was leveraged to examine mediator of the efficacy of a positive affect intervention for extending the benefits of CM.

Methods: An autoregressive cross-lagged model was fit to determine if reductions in HIV viral load were mediated by intervention-related increases in positive affect and decreases in stimulant use measured in four waves over 15 months.

Results: Higher baseline positive affect predicted significantly lower self-reported stimulant use immediately following the 3-month CM intervention period, even after controlling for self-reported stimulant use at baseline. Moreover, decreased stimulant use emerged as an independent predictor of long-term reductions HIV viral load at 15 months, even after adjusting for HIV viral load at baseline and the residual effect of the positive affect intervention.

Conclusions: Findings underscore the importance of durable reductions in stimulant use as a primary intervention target that is essential for optimizing the clinical and public health benefits of HIV treatment as prevention.

1. Introduction

Treatment as Prevention (TasP) is an evidence-based, biomedical approach where achieving viral suppression with antiretroviral therapy (ART) leads to a 96% reduction of onward HIV transmission while optimizing health outcomes (Holmes et al., 2017; Eshleman et al., 2017; Rodger et al., 2016). In the modern ART era, many patients take one pill daily and can achieve viral suppression at lower rates of adherence, which has begun to address problems of resistance, toxicity, and tolerability (Looney et al., 2015; Nance et al., 2018). Along with dramatic increases in viral suppression in the United States, modern ART regimens have led to significant increases in life expectancy, such that a person diagnosed with HIV today is projected to have a life expectancy that approximates someone without HIV (Samji et al., 2013). With the evidence of effectiveness of TasP, the World Health Organization provided new guidelines for a TasP strategy, initiating all those diagnosed with HIV into ART, regardless of their CD4+ T-cell count (World Health Organization, 2012). In 2014, the United Nations Programme on HIV and AIDS (UNAIDS) launched the 90–90-90 targets for 2020 to: 1) diagnose 90% of all HIV positive persons; 2) deliver ART to 90% of those diagnosed; and 3) achieve viral suppression in 90% of those on ART (Levi et al., 2016). Despite the unprecedented effectiveness of TasP, expanded approaches are needed to

optimize its clinical and public health benefits with marginalized, underserved populations such as people who use substances who are at highest risk of experiencing difficulties with managing HIV treatment and more likely to engage in transmission risk behavior (Carrico et al., 2016; Mayer et al., 2014; Shoptaw et al., 2013).

There is a preponderance of evidence linking stimulant use with amplified risk for HIV acquisition and onward transmission, especially among sexual minority men who engage in methamphetamine use (Colfax et al., 2010; Mayer et al., 2006). Furthermore, people living with HIV who use stimulants continue to struggle with engagement along the HIV care continuum. Not only do people who use stimulants initiate ART at lower CD4+ cell counts, but they are also less likely to be retained in HIV care (Carrico et al., 2011; Horvath et al., 2013). Difficulties with ART adherence and persistence, in turn, lead to elevated viral load and thereby increasing the risk for HIV clinical progression and onward HIV transmission (Carrico et al., 2014; Carrico et al., 2011; Cook et al., 2008; Mayer et al., 2014).

Despite the accruing evidence linking stimulant use with difficulties managing HIV treatment and amplified risk of onward HIV transmission, evidence-based interventions for sexual minority men who use stimulants are limited (Carrico et al., 2016; Colfax et al., 2010). Many interventions targeting stimulant use have employed contingency management (CM), an evidence-based behavioral approach wherein participants receive incentives as positive reinforcement for biologically confirmed abstinence of substance use (Prendergast et al., 2006). CM has also been shown effective for achieving short-term reductions in HIV viral load, but an important limitation is that reductions in viral load are not maintained after CM incentives are discontinued (Metsch et al., 2016; Petry et al., 2010).

Affect regulation has been recognized to play an important role in co-occurring substance use and HIV. Of particular interest, the Revised Stress and Coping Theory posits that positive affect (e.g., happiness, contentment, gratitude) may bolster coping efforts during experiences of chronic stress, assisting with managing stressful situations such as stimulant withdrawal, increasing responsivity to non-substance-related sources of reward, and improving HIV disease management (Folkman & Moskowitz, 2000). For instance, in one randomized controlled trial (RCT) that enrolled people newly diagnosed with HIV, a positive affect intervention significantly improved psychological adjustment and decreased antidepressant medication use compared to an attention-control condition (Moskowitz et al., 2017). Moreover, several observational studies have found that positive affect is directly or indirectly associated with decreased stimulant use (Carrico et al., 2013), better ART adherence (Carrico et al., 2010), increased odds of linkage to HIV care and lower HIV viral load (Carrico, & Moskowitz, 2014), and decreased risk of onward HIV transmission (Batchelder et al., 2018).

Affect Regulation Treatment to Enhance Methamphetamine Intervention Success (ARTEMIS) is a positive affect intervention designed to boost and extend the benefits of CM in sexual minority men living with HIV who use methamphetamine. Findings from a recently completed RCT documented the efficacy of the ARTEMIS positive affect intervention for improving mindfulness and reducing methamphetamine craving during CM (Carrico et al., 2018b). Furthermore, the ARTEMIS positive affect intervention has

demonstrated efficacy for achieving durable and clinically meaningful reductions in HIV viral load that were paralleled by increases in positive affect and decreases in stimulant use (Carrico et al., 2019b). The primary objective of the present longitudinal study was to examine intervention-related mechanisms accounting for long-term reductions in HIV viral load. Specifically, we hypothesized that intervention-related increases in positive affect as well as reductions in stimulant use would mediate the efficacy of the intervention for reducing viral load over 15 months.

2. Methods

2.1. Recruitment and screening.

From 2013–2017, a total of 184 individuals were recruited for this RCT from a community-based CM program, with flyers and palm cards distributed in the community, and via an incentivized snowball sampling method where eligible participants received up to $30 for referring other eligible participants. To be eligible for this Phase II RCT, participants were required to meet the following inclusion criteria: 1) 18 years of age or older; 2) report anal sex with a man in the past 12 months; 3) speak English; 4) provide documentation of HIV-positive serostatus (i.e., letter of diagnosis or being on ART medications other than tenofovir disoproxil fumarate/emtricitabine that were matched via photo identification); and 5) provide a urine or hair sample that was reactive for methamphetamine. As shown in Figure 1, of the 161 participants who completed a screening visit 16 (10%) were excluded because they did not test reactive for methamphetamine, five (3%) declined to participate, and four (2%) did not meet other inclusion criteria. Participants could receive up to $400 and an iPod shuffle for completing all research-related visits for this RCT.

All relevant procedures were approved by the Institutional Review Board for University of California, San Francisco with reliance agreements from the Univesity of Miami and Northwestern University (www.clinicaltrials.gov identifier NCT01926184). All participants completed a signed informed consent and a certificate of confidentiality was provided by the National Institute on Drug Abuse. The University of California, Los Angeles Data Safety and Monitoring Board for Addiction Medicine held annual meetings to review participant-related events and overall progress for this RCT. There were no adverse events or serious adverse events.

2.2. Run-in period and randomization.

Eligible participants completed a waiting period prior to randomization (i.e., run-in) that entailed five separate visits: 1) a baseline assessment with a peripheral venous blood sample; 2) three CM urine screening visits (regardless of the toxicology results); and 3) a separately scheduled randomization visit where the first session of the positive affect intervention or attention-control condition was delivered after randomization. Participants who did not complete the run-in period were not randomized. Of the 136 participants who were eligible and consented to participate in the RCT, 110 (81%) completed the run-in period and were randomized during the first eight weeks of CM. Randomization was accomplished using a computer-generated sequence with randomly permuted block sizes of 2, 4, and 6 to

guard against subversion. Only the study data manager had access to the computer- based randomization algorithm.

2.3. Assessments.

Participants completed a baseline assessment during the run-in period that included self-report measures, a urine sample for on-site toxicology screening, and a peripheral venous blood sample. Participants completed follow-up assessments at three, six, 12, and 15 months after the beginning of CM that included computer-based administration of self-report measures and a urine sample for on-site toxicology screening. Peripheral venous blood samples to measure HIV disease markers were collected at baseline, six, 12, and 15 months. In the 110 participants randomized, follow-up rates at three (89%), six (88%), 12 (80%), and 15 (71%) months were acceptable with no significant differences between the experimental conditions. Follow-up assessments were completed in August of 2018.

2.4. Community-based CM program.

This RCT was conducted in partnership with a community-based, 3-month CM program for sexual minority men who use methamphetamine that is operated by the San Francisco AIDS Foundation (Gomez et al., 2017). CM was delivered separately from the individual intervention or attention-control sessions. Urine sample collection is directly observed by CM program staff. The voucher for the initial sample that was non-reactive for methamphetamine and cocaine metabolites was worth $2.00. Vouchers increased in value by 25 cents for each consecutive stimulant-free sample to a maximum of $10.00. Participants earned an $8.50 bonus voucher for every third consecutive stimulant-free sample. Participants who provided a reactive urine toxicology result for stimulants could return to their place in the escalating reinforcement schedule after producing three consecutive urine samples that were non-reactive for methamphetamine and cocaine metabolites. The total possible reinforcement of stimulant abstinence during thrice-weekly urine screening over the three months was $330.

2.5. Positive affect intervention.

ARTEMIS is a multi-component, individually delivered 5-session intervention designed to increase positive affect. The ARTEMIS intervention protocol consists of eight core skills that have been shown to increase positive affect and improve psychological adjustment in prior clinical research (Moskowitz et al., 2017). Informed by prior research examining the efficacy of mindfulness-based relapse prevention (Moskowitz et al., 2017), participants also completed meditation exercises during ARTEMIS intervention sessions to further enhance mindfulness and assist individuals in coping more effectively with methamphetamine withdrawal. Participants received a workbook and an iPod shuffle that was pre-loaded with meditation exercises. Participants received $20 cash for completing each individual session, and 49 (89%) completed all five sessions.

2.6. Attention-control condition.

The attention-control condition consisted of five sessions that included face-to-face administration of psychological measures and neutral writing exercise (Boiler et al., 2013).

We chose an attention-control to provide comparable contact time with study staff and identical incentives. Participants were instructed to write as if they were reporting facts without going into thoughts or feelings about the events (e.g., plans for the next 24 hours). Participants received $20 cash for completing each attention-control session and an iPod with three pre-loaded popular songs. A total of 49 (89%) participants completed all five attention-control sessions.

2.7. Fidelity monitoring.

Facilitators with master's level training in public health or counseling were provided with a detailed manual. Audio recordings of ARTEMIS intervention sessions were reviewed by a clinical supervisor during weekly individual supervision to provide feedback on delivery of intervention content and process-oriented techniques. Monthly group supervision meetings provided opportunities for case presentation and ongoing discussions about optimizing the delivery of both the ARTEMIS intervention skills and attention-control protocol. Audio recordings of intervention sessions were reviewed by an independent fidelity monitor to provide more detailed feedback to facilitators regarding adherence to the ARTEMIS intervention content, interpersonal skills, rapport, and session flow. A total of 71 of the 259 competed ARTEMIS intervention sessions (27%) were coded using fidelity rating checklists with detailed feedback provided to facilitators.

2.8. Measures.

The primary outcome was $\log_{10}$ HIV viral load at 15 months, which was measured using the Abbott RealTi*me* HIV-1 reverse transcription -polymerase chain reaction assay. This assay reliably detects HIV RNA from 40 to 10,000,000 copies/mL. Positive affect was measured using the 26-item Differential Emotions Scale (DES) to assess the frequency of positive and negative affect during the past week, wherein participants rated how frequently they felt a particular emotion during the past week (Cronbach's alpha = 0.89). Finally, participants self-reported the number of days using powder cocaine, crack-cocaine, or methamphetamine in the past 30 days. The highest number of days participants reported using any of these stimulants was selected.

2.9. Statistical analyses.

All statistical analyses were performed using SAS9.4 (SAS Institute, Cary NC). Consistent with our previously reported findings (Carrico et al., 2019b), intent-to-treat analyses for positive affect, stimulant use, and viral load were initially conducted (Table 2) to determine the mean difference between treatment arms at each time point (i.e., baseline, 3-month, 6-month, 12-month), estimated using generalized linear modeling (PROC GLM in SAS9.4). Then, in order to model the covariance structure, bivariate repeated measurement models with a Kronecker product covariance structure were fit to examine the intra- and inter-variable correlations of the measurement errors (PROC MIXED / REPEATED statement in 9.4). The Kronecker product covariance structure was chosen for its advantages in modeling the correlation pattern separately for each repeated factor with multivariate repeated measures data, which improves accuracy, makes model fitting easier, and allows for the evaluation of the joint evolution of variables (Galecki, 1994; Verbeke, Fieuws, Molenberghs, & Davidian, 2014). Moreover, the approach uses fewer parameters than an

unstructured model, with the Kronecker product combining the factor-specific covariance structures into an overall correlation model (Galecki, 1994; Verbeke et al., 2014). In Table 3, the interrelationship among the three variables (i.e., positive affect, stimulant use, and viral load) were noted on the estimates out of the random effects portion, with slope parameters reflecting the average change of the variable over time. For the analyses, we used an unequal time variable coding for assessments at baseline, 3-, 6-, 12- and 15 months. Although there were no differences in results between the coded time and days elapsed from baseline, we obtained a better goodness-of-fit statistic (e.g., the AIC was lower when we used coded time variable). As such, Table 3 presents the results from the models using coded time rather than days elapsed from the baseline visit.

To test our hypothesized model (see Figure 2), an autoregressive cross-lagged model was fit so that measurments of both positive affect and stimulant use at a given time point t were simultaneously regressed on measurements of these two variables at the immediately preceding time point, t-1 (Selig & Little, 2012). The PROC CALIS procedure was used on SAS9.4.The autoregressive cross-lagged model provided information about whether positive affect at time t-1 predicted stimulant use at time t, above and beyond the t-1 observations of stimulant use, and similarly, whether stimulant use at time t-1 predicted positive affect at time t, over and above the measurements of positive affect at time t-1. In addition, our model included treatment group as a exogenous predictor for each time point measurement. Ultimately, the autoregressive cross-lagged model was used to investigate whether the cross-lagged paths significantly improved the overall fit of the model. Any significant paths accounted for the correlations among the variables within a wave and controlled for previous scores on the outcome variable and other predictors in the model to allow for the estimation of the unique relationship between study variables.

With regards to invariance testing, we assessed whether the pattern of results as invariant across time. Each cross-lag path was constrained to be equal across time and compared to an unconstrained model where paths were left free to vary. A chi-square difference test of relative fit was used to ascertain whether there was a difference in model fit between the constrained and unconstrained models. Non-significance would indicate no difference in fit between the two models and the more parsimonious constrained model would be kept for further hypothesis testing. Model fit was determined using the chi-square value, degrees of freedom, comparative fit index (CFI), and the root mean square error of approximation (RMSEA) indicators of goodness-of-fit (Hu & Bentler, 1999), and we used Hu and Bentler's recommended cut-off criteria for a well-specified or close-fitting model as CFI/TLI > 0.95 and a RMSEA < 0.06. To handle missing data, we used full information maximum likelihood estimation (FIML).

3. Results

Table 1 presents the study sample characteristics. Overall, participants were 43 years old (SD = 9, range 23 to 59), identified as non-white (57.3%), identified as exclusively gay (76%), had more than a high school education (77%), had an income less than $16,000 (65%), and had been diagnosed with HIV for 13 years (SD = 9, range= .04 to 36.15). Table 2 presents the differences in means of positive affect, stimulant use, and viral load between

the treatment and control groups for each time point (i.e., baseline, 3-month, 6-month, and 12 months). At 6 months, significant differences are observed between treatment groups for positive affect (Mean (SE) = 4.49 (1.73*),p < 0.01),* stimulant use (Mean (SE) = −3.57 (1.70*),p < 0.05),* and HIV viral load (Mean (SE) = −1.13 (0.27), *p < 0.001).* The same is observed at 12 months for positive affect (Mean (SE) = 4.43 (2.28*),p < 0.05),* stimulant use (Mean (SE) = −3.91 (2.02*),p < 0.05),* and HIV viral load (Mean (SE) = −0.59 (0.30), *p < 0.05).* Consistent with our previously reported findings (Carrico et al., 2019b), mean differences over time were found significant.

In order to examine the intra- and inter-marker correlations of the measurement errors, bivariate repeated measurement models with a Kronecker product covariance structure were conducted. Table 3 presents the results of the fitted mixed models, where the slope parameters reflect the average change of the variables over time, and the estimated correlation coefficients of the random effects portion reflect the interrelationships among the three variables. Based on the fit statistics (−2 Res Log Likelihood, AIC, BIC; See Table 3), the models with a continuous-time first-order autoregressive covariance structure (i.e., UN@AR) provide a good fit to the data. The results also indicate a strong significant negative correlation between positive affect and stimulant use ($\sigma xy = -71.62$, *p < 0.001);* a strong significant negative correlation between positive affect and viral load ($\sigma xz = -57.43$,*p < 0.001);* and a significant positive correlation between stimulant use and viral load ($\sigma yz = 7.53$, *p < 0.05).* Although the models with an unstructured covariance structure (UN@UN) provide a better fit to the data, the continuous-time first-order autoregressive covariance structure was chosen for its parsimony in the number of covariance parameters as well as its common utilization in studies with multivariate longitudinal data (Galecki, 1994; Verbeke et al., 2014).

3.1. Final Model

Figure 3 graphically depicts the final parsimonious model outlining the longitudinal relationship between positive affect and stimulant use on the outcome viral load. The model showed acceptable fit to the data ($x^2(35) = 74.36$, p < 0.0001; CFI = 0.87; RMSEA = 0.08). For all time waves, prior positive affect and stimulant use predicted later positive affect (Autocorrelation [AR] = 0.36, [95% CI = 0.29 – 0.44]) and stimulant use (AR = 0.43, [95% CI = 0.34 – 0.51]), respectively. The longitudinal path for the effect of positive affect on stiimulant use (T1 to T2) was significant, suggesting that higher positive affect at baseline predicted lower stimulant use at 3 months, even after controlling for prior stimulant use at T1. All other cross- lagged paths were non-significant

4. Discussion

Results from this RCT demonstrate that higher baseline positive affect predicts significantly lower self-reported stimulant use immediately following the 3-month CM intervention period, even after controlling for self-reported stimulant use at baseline. Moreover, decreased stimulant use emerged as an independent predictor of long-term reductions HIV viral load at 15 months, even after adjuring for HIV viral load at baseline and the residual effect of the ARTEMIS positive affect intervention. We have previously

demonstrated the efficacy of the ARTEMIS positive affect intervention for achieving durable and clinically meaningful reductions in HIV viral load following CM that were paralleled by significant increases in positive affect and decreases in stimulant use (Carrico et al., 2019b). Interestingly, those randomized to receive the ARTEMIS positive affect intervention continued to display lower HIV viral load at 15 months, even after adjusting for positive affect and stimulant use.

Higher baseline positive affect emerged as an independent predictor of lower self-reported stimulant use at three months. In other words, positive affect was an important prognostic indicator for greater success in reducing stimulant use during CM. It may be that higher positive affect serves as an indicator of positive psychological traits or decreased severity of stimulant use at baseline. Incorporating positive affect assessments into clinical intakes may assist providers in deciding which patients are most likely to benefit from CM. Further clinical research is needed to establish clinically validated cut points for the level at which positive affect is linked to better outcomes following CM and other evidence-based approaches to substance use disorder treatment.

Another important finding from this study was that stimulant use independently predicted higher viral load at 15 months, which underscores the central importance of reducing stimulant use in this population. This lends further empirical support to a large body of research documenting the association of stimulant use with elevated virai load among people living with HIV (Ellis et al., 2003; Carrico et al., 2011), even in the TasP era (Carrico et al., 2019a). Although positive affect was associated with lower self-reported stimulant, there were no direct or indirect effects of positive affect on viral load at 15 months. These findings underscore the importance of achieving durable reductions in stimulant use as a primary intervention target for interventions designed to optimize the clinical and public health benefits of TasP in sexual minority men living with HIV who use methamphetamine. Further clinical research is needed to test novel approaches to optimize the durable efficacy behavioral and biomedical interventions for addressing chronic, relapsing stimulant use disorders in people living with HIV.

Interestingly, those randomized to receive the ARTEMIS positive affect intervention during CM continued to display significantly lower HIV viral load at 15 months, even after adjusting for baseline viral load and self-reported stimulant use. This highlights the possibility that there may be other unmeasured mediational pathways that partially explain the efficacy of the ARTEMIS positive affect intervention for achieving durable and clinically meaningful reductions in HIV viral load following CM. Informed by Revised Stress and Coping Theory,more definitive randomized controlled trials are needed to test other plausible social and psychological mediators of the ARTEMIS positive affect intervention. Elucidating the key theory-based mediators would advance our understanding of the underlying mechanism(s) of the multi-component ARTEMIS positive affect intervention, which would guide efforts to augment its effectiveness.

Findings from this RCT should be interpreted in context of some limitations. Given the modest sample size, tests of mediation did not have sufficient statistical power to test indirect effects. Because this RCT was conducted in San Francisco and focused exclusively

on sexual minority men living with HIV who use stimulants, important questions remain regarding the generalizability of these results in other settings as well as with other populations. Clearly, more definitive RCTs of this promising model of delivering an ARTEMIS positive affect intervention during CM for optimizing TasP are needed.

Despite these limitations, this RCT provides important information to guide clinical practice with sexual minority men living with HIV who use methamphetamine. Positive affect at baseline is a key prognostic indicator for greater success during CM. Incorporating measures of positive affect into clinical intake assessments could guide the development of comprehensive care plans to address co-occurring stimulant use and HIV in sexual minority men. Furthermore, stimulant use disorders are chronic, relapsing conditions that often require ongoing treatment to achieve durable and clinically meaningful reductions in stimulant use. Findings from this study underscore the importance of durable reductions in stimulant use as a primary intervention target that is essential for optimizing the clinical and public health benefits of TasP.

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Highlights

- Higher positive affect predicts significantly lower stimulant use after CM

- Decreased stimulant use independently predicts long term reductions in viral load

- Durable reductions in stimulant use should be used as a primary treatment target
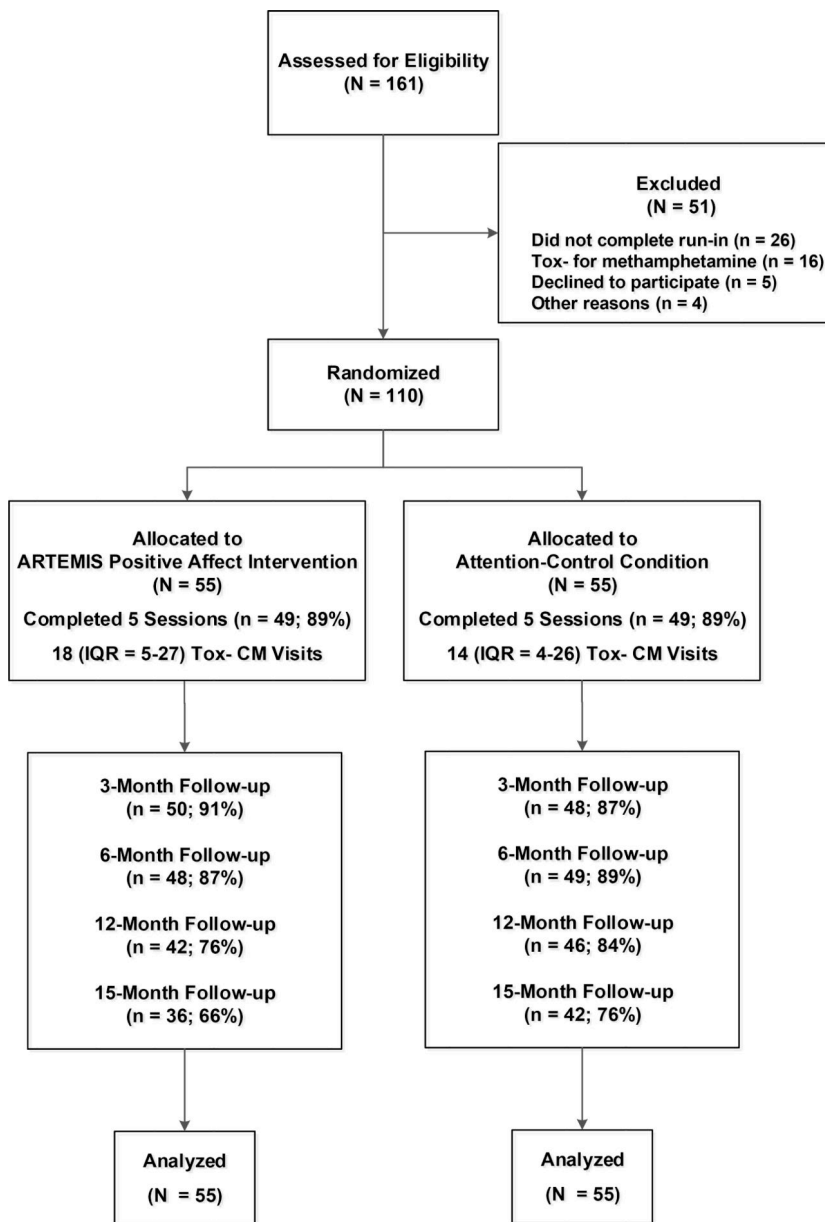
Figure 1:
Screening, randomization, and follow-up for ARTEMIS participants
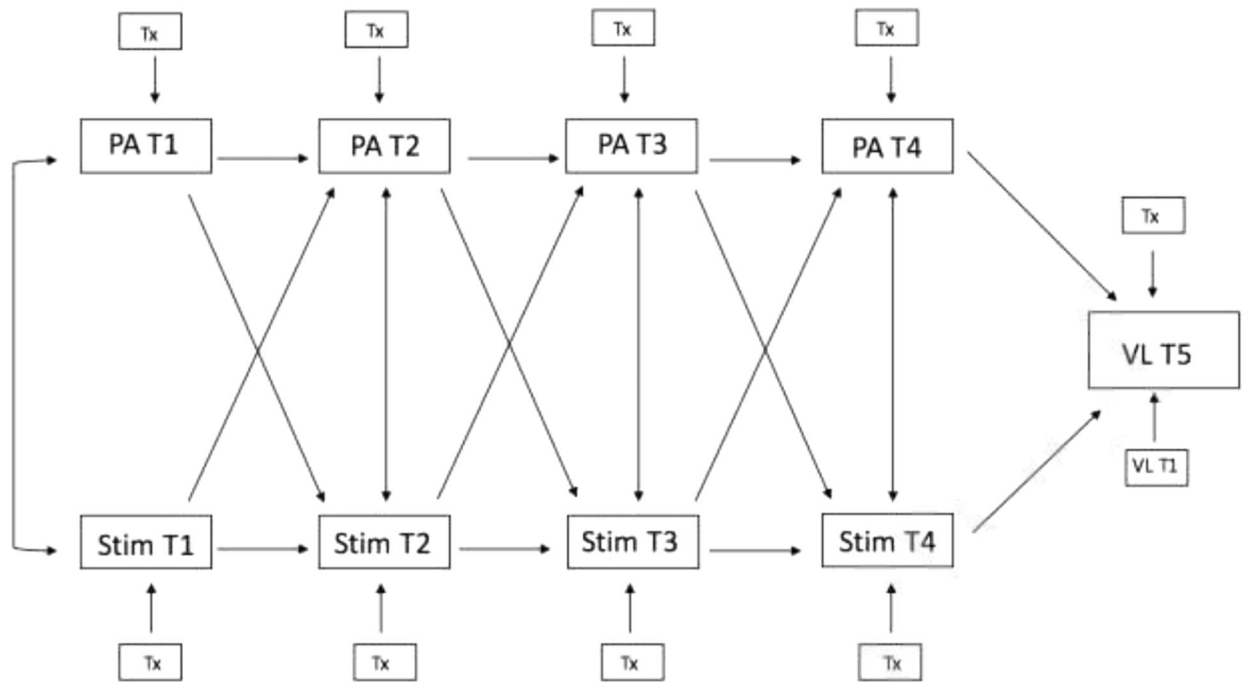
PA = Positive affect; **Stim** = Days stimulant use in past 30 days; **VL** = viral load; **tx** = treatment group
T1 = Time 1 (baseline); **T2** = Time 2 (3 month); **T3** = Time 3 (6 month); **T4** = Time 4 (12 month); **T5** = Time 5 (15 months)

Figure 2:
Hypothesized autoregressive cross-lagged model

PA = Positive affect; **Stim** = Days stimulant use in past 30 days; **VL** = viral load; **tx** = treatment group
T1 = Time 1 (baseline); **T2** = Time 2 (3 month); **T3** = Time 3 (6 month); **T4** = Time 4 (12 month); **T5** = Time 5 (15 months)
*$p < 0.05$
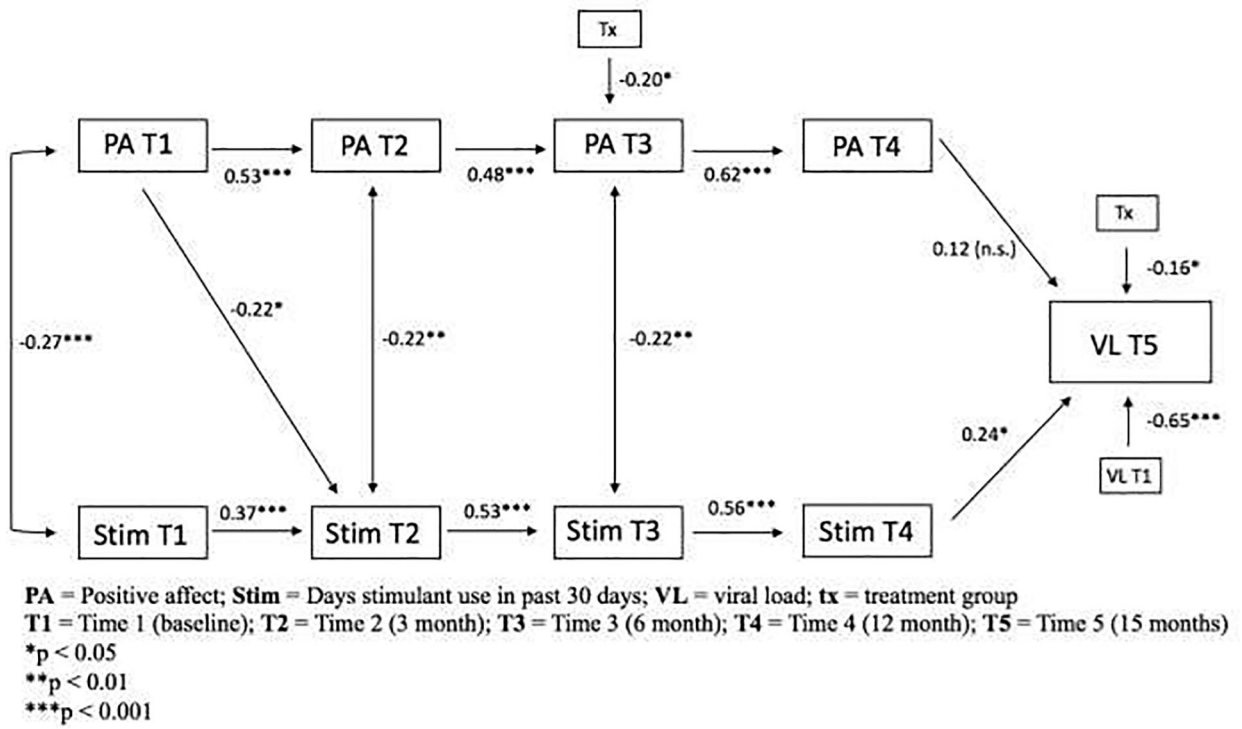**$p < 0.01$
***$p < 0.001$

Figure 3:
Final parsimonious autoregressive cross-lagged model

Table 1:

Baseline characteristics of ARTEMIS trial participants

	All (n=110)	ARTEMIS (n=55)	Attention-Control (n=55)	p-value
	M (SD)	M (SD)	M (SD)	
Age	43.2 (8.9)	43.2 (9.2)	43.2 (8.5)	0.88
Time since HIV diagnosis (Years)	12.9 (8.6)	13.4 (8.9)	12.5 (8/4)	0.62
CD4+ T-cell count (cells/mm^3)	620.9 (298.1)	642.9 (272.8)	639.9 (313.6)	0.99
	n (%)	n (%)	n (%)	
Race/Ethnicity				0.12
Black/African American	18 (16.4)	9 (8.2)	9 (8.2)	
White	47 (42.7)	18 (32.7)	29 (52.7)	
Hispanic/Latino	32 (29.1)	21 (38.2)	11 (20.0)	
Other ethnic minority	13 (11.8)	7 (12.7)	6 (10.9)	
Education				0.62
Less than high school	8 (7.3)	5 (9.1)	3 (5.5)	
HS graduate	17 (15.5)	8 (14.6)	9 (16.4)	
Some college/trade school	57 (51.8)	25 (45.5)	32 (58.2)	
College graduate	17 (15.5)	10 (18.2)	7 (12.7)	
Post graduate	11 (10.0)	7 (12.7)	4 (7.3)	
Income				0.26
< $4,999	16 (14.5)	8 (14.8)	8 (14.6)	
$5,000 – $11,999	28 (35.5)	9 (16.7)	19 (34.6)	
$12,000 – $15,999	27 (24.5)	14 (25.9)	13 (23.6)	
$16,000 – $24,999	12 (10.9)	6 (11.1)	6 (10.9)	
$25,000 – $34,999	9 (8.2)	4 (7.4)	5 (9.1)	
$35,000 – $49,999	9 (8.2)	7 (13.0)	2 (3.6)	
>$50,000	8 (7.3)	6 (11.1)	2 (3.6)	
HIV viral load 200 copies/mL	15 (13.6)	6 (11.1)	9 (16.7)	0/14

ARTEMIS = affect regulation to enhance methamphetamine intervention success

Table 2:

Differences in means for positive affect, stimulant use, and viral load between the treatment and control groups for each time point (i.e., baseline, 3-month, 6-month, and 12 months)

Variable	Group	Baseline		3-month		6-month		12-month	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Positive Affect	Treatment	33.27	7.62	34.82	8.41	35.44	8.12	35.17	10.11
	Control	31.25	8.76	32.27	9.47	30.96	8.84	30.74	11.19
		Mean (SE)		*Mean (SE)*		*Mean (SE)*		*Mean (SE)*	
	Mean difference between group by study visit ‡	2.02 (1.57)		2.55 (1.81)		4.49 (1.73) **		4.43 (2.28) *	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Days of Stimulant use in past 30 days	Treatment	10.31	9.89	5.30	7.68	4.55	7.72	5.33	8.05
	Control	9.18	9.26	8.50	9.29	8.12	8.91	9.24	10.59
		Mean (SE)		*Mean (SE)*		*Mean (SE)*		*Mean (SE)*	
	Mean difference between group by study visit ‡	1.13 (1.83)		−3.20 (1.72)		−3.57 (1.70) *		−3.91 (2.02) *	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Viral Load	Treatment	1.04	1.22	-	-	0.69	0.75	0.93	1.21
	Control	1.42	1.40	-	-	1.82	1.61	1.52	1.51
		Mean (SE)		*Mean (SE)*		*Mean (SE)*		*Mean (SE)*	
	Mean difference between group by study visit ‡	−0.39 (0.25)		-		−1.13 (0.27) ***		−0.59 (0.30) *	

*
$p<0.05$

**
$p<0.01$

***
$p<0.001$

‡estimated using generalized linear modeling

Table 3:

Bivariate mixed models with a Kronecker product covariance (after controlling for treatment group)

	Positive Affect (x) vs. Stimulant Use (y)		Positive Affect (x) vs. Viral Load (z)		Stimulant Use (y) vs. Viral Load (x)	
	UN@AR	UN@UN	UN@AR	UN@UN	UN@AR	UN@UN
Fixed effect						
Slope_x	3.05(0.52)***	2.48(0.41)***	4.13(0.65)***	6.56(0.51)***		
Slope_y	−3.03(0.32)***	−2.86(2.60)***			−0.56(0.27)*	−0.34(0.24)
Slope_z			−0.66(0.14)***	−0.94(0.13)***	−0.13(0.13)	−0.10(0.12)
Random effect (covariance)						
σxy	−71.62(8.50)***	−87.15(12.21)***				
σxz			−57.43(10.12)***	−62.66(15.31)***		
σyz					7.53(2.32)*	9.86(2.87)***
Fit statistics						
−2LnL	5605.5	5559.7	4368.4	4298.7	51.93.9	5148.9
AIC	5613.5	5593.7	4376.4	4332.7	5201.9	5182.9
BIC	5624.3	5639.6	4387.2	4378.6	5212.7	5228.8

*
$p<0.05$

**
$p<0.01$

***
$p<0.001$